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APPLICATION OF CONTAINER TECHNOLOGY
TO
UNITED STATES MARINE CORPS
TACTICAL ELECTRIC GENERATOR SYSTEMS

John S. Walker

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THESIS

Application of Container Technology
to
United States Marine Corps
Tactical Electric Generator Systems

by

John S. Walker

June 1976

Thesis Advisor:

J. C. Totten

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Application of Container Technology
to
United States Marine Corps
Tactical Electric Generator Systems

by

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Major, United States Marine Corps
B.M.E., Rensselaer Polytechnic Institute, 1963

Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN MANAGEMENT

from the

NAVAL POSTGRADUATE SCHOOL
June 1976

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LIST OF FREQUENTLY USED ABBREVIATIONS

AFOE - Assault Follow On Echelon
FMF - Fleet Marine Force
FSSG - Force Service Support Group
ISO - International Organization for Standardization
JLRB - Joint Logistics Review Board
KW - Kilowatt
LSA - Logistic Support Area
MAB - Marine Amphibious Brigade
MAF - Marine Amphibious Force
MAGTF - Marine Air-Ground Task Force
MAU - Marine Amphibious Unit
MAW - Marine Air Wing
MEPDIS- Modular Expeditionary Power Distribution System
MEPGS - Mobile Electric Power Generating Sources
MHE - Material Handling Equipment
MSC - Military Sealift Command
NDRF - National Defense Reserve Fleet
OSDOC - Offshore Discharge of Containerships
TACOSS- Tactical Container Shelter System
T/E - Table of Equipment Allowances

I. INTRODUCTION

During the past twenty years the United States transportation industry has been revolutionized by the advent of large-scale cargo containerization. Containerization has caused the virtual restructuring of the Merchant Fleet and has engendered entire new container-based land transportation systems and port complexes.

Since the Department of Defense relies on commercial transportation assets to a large extent in both peacetime and wartime, containerization has and will significantly affect military logistics operations.

The majority of military-sponsored studies of containerization have considered the container as a transportation medium for general cargo. These studies (See references) have convincingly established that the advantages of containerization realized by civilian operations are in large measure transferrable to the military environment. These advantages have appeared in terms of manpower reductions, increased shipping utilization, decreased port congestion, and increased cargo protection.

This study focuses on the possible application of container technology to a particular type of material: Marine Corps Generators. The technology will be considered first as the traditional transportation medium--that is, as a means of moving generators from a support base to an

operational theater, with the containers being returned expeditiously to the transportation system. Secondly, the use of dedicated containers--or shelters--will be considered. In this case, the generator will be housed permanently in a container-compatible structure for both transportation and for operation.

These two potential methods of employment will be considered in the context of current and projected Marine Corps' organization and missions.

Finally, the study will address two basic questions: Can generators be containerized? For those generators which can be containerized, should they be containerized?

II. BACKGROUND

A. THE U.S. MERCHANT MARINE

The U.S. Merchant Marine is an essential support component to the Department of Defense in both peacetime and wartime circumstances. That the government has a vital interest in maintaining a viable U.S. Merchant fleet is reflected by legislation going back to the Cargo Preference Act of 1904, which required that all military cargo be shipped in U.S. flag vessels. A 1954 revision of this act required that at least 50 percent of all military cargo be transported in U.S. ships [1, p. 53]. The 1954 "Wilson-Weeks" agreement between the DOD and the Department of Commerce, which is still in effect, establishes the following priorities for augmenting DOD operated shipping:

1. Regularly scheduled U.S. carriers (i.e., berth space).
2. Charter of U.S. carriers.
3. Shipping provided by National Shipping Authority or General Agency Agreement.
4. Foreign carriers, but only in emergency situation [2, Part I, p. 24].

In addition to the U.S. Merchant Marine, the DOD has two other sources for shipping assets. The Military Sealift Command (MSC) Nucleus Fleet is a compound of a relatively small number of government owned and operated ships used to

meet the need for special shipping capabilities not normally available from civilian sources. In 1965 there were 89 ships in the Nucleus Fleet [1, p. 54]. There are currently 23 [3].

The National Defense Reserve Fleet is composed primarily of ships constructed during World War II. The NDRF has declined from a 1954 high of 2277 ships to 487 in 1974, some 328 of which were scheduled for retention.

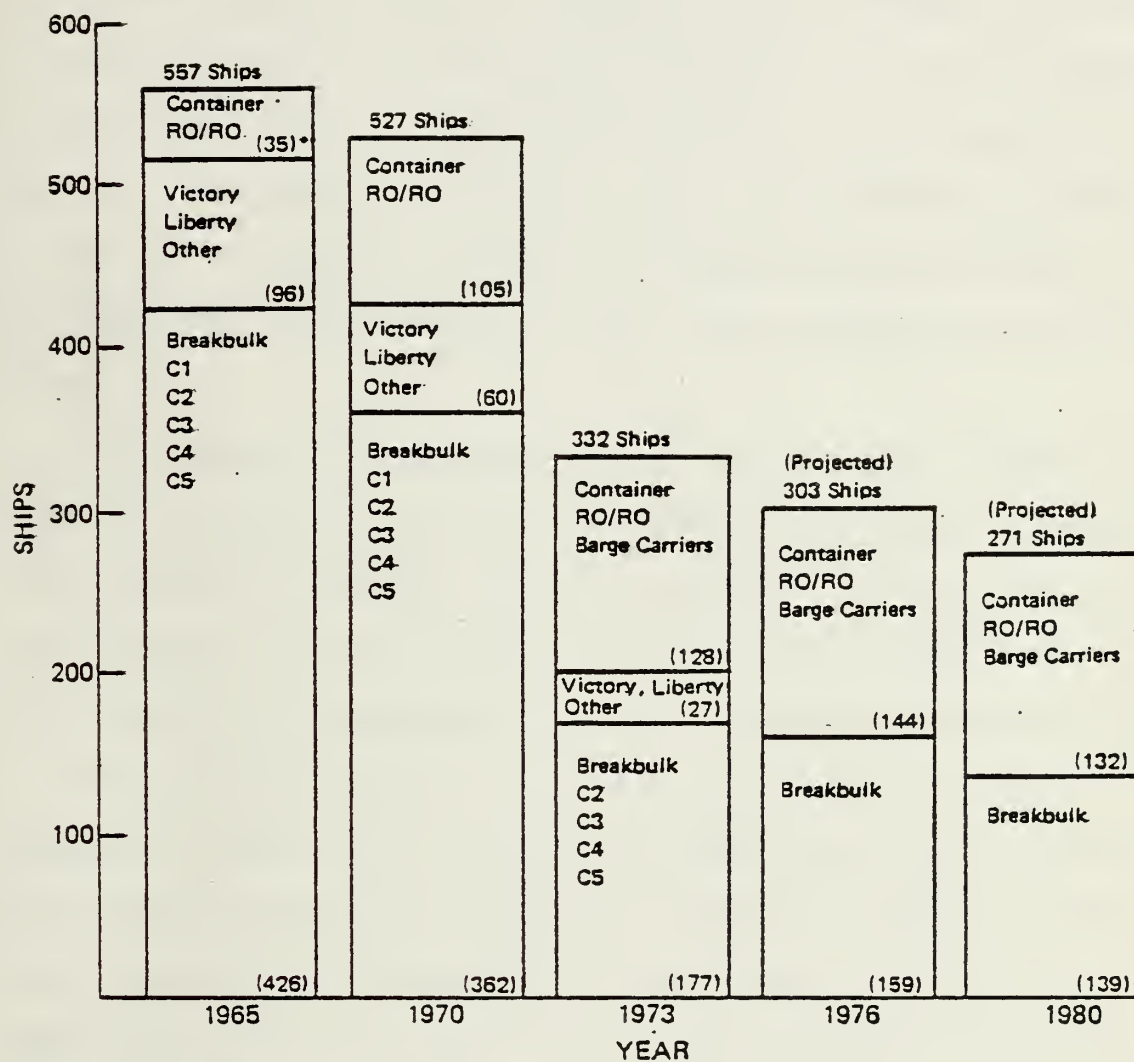
All of the above figures include all types of ships: dry cargo, tanker, and other.

In any major outbreak of hostilities, the DOD and the military services would be dependent to a large extent on the Merchant Marine to augment MSC and NDRF assets. During the Vietnam War, which was of relatively low intensity, some Merchant Marine ships were committed. There was even use of foreign flag ships due to the limited number of U.S. ships available [1, p. 58].

The almost total obsolescence of the NDRF and the declining numbers of the MSC ships imply further reliance on the civilian fleet in any future contingency.

Despite direct government construction and operating subsidies beginning in 1936, and totaling \$457 million in 1974 [4, p. 68], the size of the U.S. Merchant fleet has progressively declined.

Figure 1 [5, p. 13] graphically displays this reduction for general dry cargo between 1965 and 1973, with projections through 1980. Considering the extended lead time required for ship construction, these projections are probably very accurate.



*Numbers in (brackets) indicate ships in each category.

SOURCE: Toward An Improved U.S. Merchant Marine [57].

Figure 1. Trend in Composition of U.S. Privately Owned General Cargo Fleet

In addition to these quantitative factors, Figure 1 also shows an overwhelming shift from "break-bulk" type dry cargo ships to container ships. Significantly, although the number of ships decreases by more than one half, the total capacity of the fleet remains essentially stable at approximately five million dead weight tons [5, p. 157]. This fact is attributable to the efficiencies inherent in containerization, which in turn has been the driving force in the transformation of the merchant fleet.

This shift--"The Container Revolution"--has allowed the military services to achieve considerable savings in manpower and material in routine supply operations. It has also forced consideration of the changing merchant fleet composition in the context of contingency and full mobilization situations.

The old break-bulk fleet had flexibility in terms of both numbers of ships and the types of cargo which could be handled. The logistic system and materials handling equipment (MHE) were designed to accommodate a large number of relatively small (pallet-sized) loads. The work was labor-intensive.

Containerization has reduced the total number of ships required to meet overall commercial transportation needs. It depends on using a limited number of relatively large loads in an equipment-intensive environment.

B. CONTAINERIZATION

A container can be defined as:

...an article of transportation equipment:
(a) of a permanent character and accordingly strong enough to be suitable for repeated use;

(b) especially designed to facilitate the carriage of goods by one or more modes of transportation without intermediate reloading; (c) fitted with devices permitting its ready handling, particularly its transfer from one mode of transport to another; (d) so designed to be easy to fill and empty; (e) having an internal volume of 1 m³ (35.3 ft.³) or more [6, p. 57].

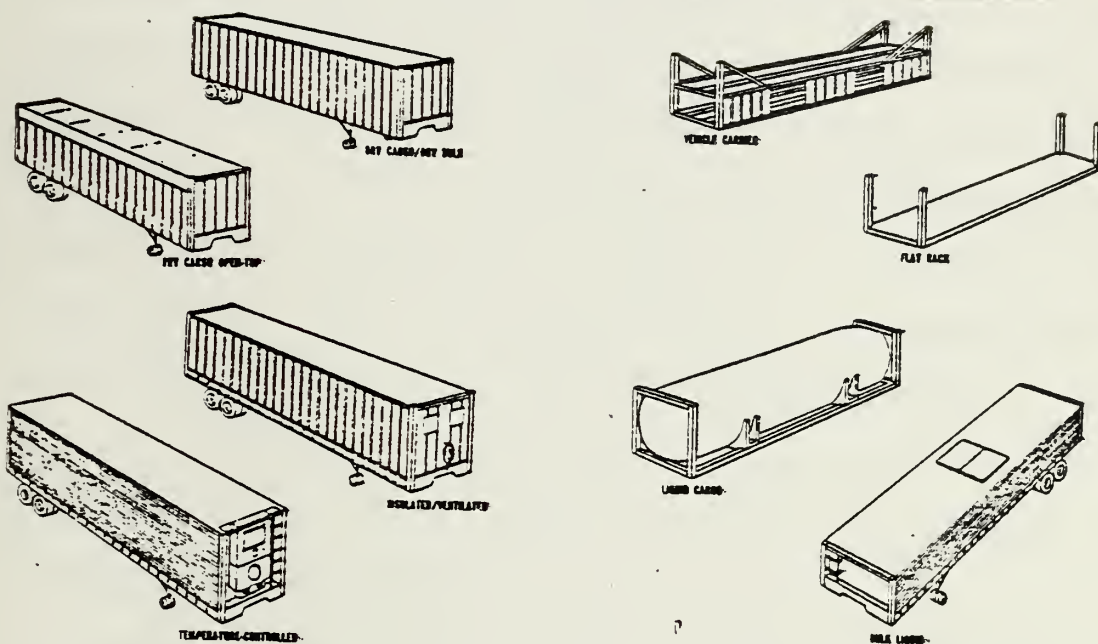
Containers have rigid steel frames as their primary structural component and are capable of being stacked at least several containers high. Vertical corner posts are connected by sills and headers and covered by a relatively thin skin material of steel, aluminum or fiberglass-reinforced plywood (FRP). The posts have standard corner fittings for lifting/stacking/joining. Flooring materials are typically wood, steel or aluminum [6, p. 7-157].

Since the initial introduction of containerization to commercial transportation in the mid-1950's, there have evolved a great many types and sizes of containers. The types of interest in this study are:

--Dry Cargo Containers, which are fully-enclosed and weather-proofed, with one or more sets of doors for loading/unloading (stuffing/unstuffing).

--Flatrack or platform containers, a large pallet on which material, equipment or vehicles are lashed.

Other types of containers include open top or gondola, refrigerated, liquid tanks and automobile carriers. Figure 2 illustrates the range of containers available in the commercial sector.



SOURCE: Military Traffic Management Command Pamphlet
55-2, p. 7.

Figure 2. Types of Containers

There has been a proliferation of container sizes, with each individual steamship company initially adopting its own configuration based upon unique requirements and capabilities. Starting in the early 1960's considerable effort has been devoted to standardizing container sizes and weight limits in order to promote commonality among shipping modes and materials handling equipment. The primary organizations influencing this standardization have been the American National Standards Institute (ANSI) and the International Organization for Standardization (ISO) [6, p. 2-5]. The characteristics of standard dry cargo containers considered in this study are summarized in Figure 3. The most prevalent of these types is the 8'X8'X20', and in many cases, capacities of the containers are expressed in "twenty foot equivalents."

There appears to be a move in commercial transportation toward expanded use of containers larger than the 20-foot, in particular, the 40-foot size. It should also be noted that several steamship companies have retained their unique container size (e.g., MATSON-24-foot, Sea-Land-35-foot).

Containerships can be classed in the following categories:

- Self-sustaining containerships, having full integral equipment for loading containers from dockside into the ship and off-loading them at the destination.

- Non-self-sustaining containerships, requiring dockside equipment for loading/unloading.

NOMINAL SIZE(ft) HXWXL/ISO DESIGNATION	OUTSIDE DIMENS.(in.) ACTUAL HXWXL	GROSS WEIGHT LIMIT (lbs.)
8X8X20/IC	96X96X240	44,800
8X8X20/ID	96X96X117 3/4	22,400
8X8X6 2/3 /IE (TRICON)	96X96X77 1/2	15,680
8X8X5/IF (QUADCON)	96X96X57 1/4	11,200

SOURCE: ISO Recommendation R668, 2nd Edition, October 1970.

Figure 3. Standard Container Dimensions

--Lighter Aboard Ship (LASH) and Sea Barge (SEABEE) ships employ special lighters or barges, which are hoisted by elevators on board a "mother ship" for ocean transport. The barges may be loaded with containers, break-bulk, palletized cargo, or vehicles. At the destination the barges can be off-loaded either at dockside, or at an anchorage from which they can be floated to an off-load point. A minimum of port facilities is required for either LASH or SEABEE.

--Roll on-Roll off (RO/RO) are designed to have fully loaded vehicles and/or trailers drive directly on and off the ship.

Projected inventories of each type of ship are as follows:
[5, p. 14; 7, p. A-2; 8, p. 43]

	<u>1976</u>	<u>1980</u>
Self-Sustaining Containership	14	7
Non-Self-Sustaining Containership	91	88
LASH	20	20
SEABEE	3	3
RO/RO	17	17

C. MILITARY APPLICATION OF CONTAINERIZATION

Containerization has compelled the military to consider a number of serious problems, particularly in expeditionary and general war situations. This section will discuss the overall problems and enumerate the current alternative solutions.

The first problem, and potentially the most difficult to solve, is the unloading of containerships in undeveloped port areas. This problem is particularly acute with non-self-sustaining containerships, which comprise the bulk of the containership assets. A series of Offshore Discharge of Containerships (OSDOC) exercises was begun in 1970 (OSDOC I) and 1972 (OSDOC II). During these exercises and associated tests various unloading schemes such as mobile cranes, helicopters and lighter than air balloons (Aerocranes) have been investigated. The results indicate technical feasibility, but with varying degrees of efficiency and cost. No system has yet established a clear superiority.

The ship to shore movement of containers by means of lighters and unloading of lighters at the shore end has also been explored. Various combinations of barges, pontoon causeway sections and conventional landing craft have been tested. Also under consideration is the use of air cushion vehicles (ACV's) as lighters.

On the shore, floating and elevated causeways have been used, with the most recent tests (January 1976) yielding very encouraging results. An elevated causeway system incorporating a pneumatic turntable at its end for reversing vehicle direction, was installed successfully and served as a platform for off-loading containers from barges [9, p. 147].

Beach movement and handling of containers will require soil stabilization techniques. Conventional mattings as well as fast-curing synthetic resins have been employed successfully.

Materials handling equipment and vehicles for overland movement must be developed. Current military equipment for handling 20-foot containers weighing up to 44,800 pounds is limited to mobile cranes. Additional equipment will be required to efficiently handle the volume of containers which can be expected in the theater of operation. The Army has identified the following specific requirements: [10, Vol. II, p. J-57].

- Self-loading, Side-Carrying Container Handler, 20 to 40 foot ISO container, 67,000 pound capacity.

- Rough Terrain Forklift, 50,000 capacity.

--Rough Terrain Forklift, 15,000 capacity.

--Rough Terrain Forklift, 2,500 capacity.
(for container stuffing/stripping)

--Mobile cranes for 20 to 40 foot containers, 67,200
pound capacity (for pierside unloading of containerships).

--Semi-trailer, 22½ ton (for both break-bulk and container).

--Semi-trailer, 22½ ton, self-loading.

Containers must not only possess ocean-land intermodality, but must also be able to interface with air transportation modes. Current helicopters require slings equipped with spreader bars, and container size is limited by the weight-carrying capacity of the helicopters. The CH-53, currently the Marine Corps largest helicopter can lift a maximum of 14,800 pounds. Heavy lift helicopters now under development (CH-53E) will have weight limits of 32,000 pounds [7, p. I-3].

Transportation of 20-foot containers in C-130, C-141, and C-5A is possible with use of an adapter pallet, although additional ground material handling equipment (MHE) is required [11, p. 59-60].

The Joint Logistics Review Board (JLRB) report on containerization [12] describes containerized shipments to Vietnam starting in 1967. Three self-sustaining containerships shuttled between U.S. West Coast ports and Da Nang, RVN, each delivering an average of 226 containers and 9000 measurement tons (MTons) of cargo each 15 days. Three other non-self-sustaining ships delivered 662 containers and 24,000 MTons to Cam Ranh Bay per trip, also on a 15-day cycle [12, p. 13].

All classes of supply were shipped, including ammunition, and it was estimated that approximately two-thirds of all dry cargo could have been containerized.

It should be noted that commercial containers were not introduced into Vietnam until fixed port facilities had been constructed. Materials handling and transportation equipment as well as container off-loading were provided by a civilian contractor (SEA-LAND). Considerable use was made of CONEX type containers (75" X 82½" X 102", metal reusable shipping container, not compatible with ISO standards) both for shipping purposes and for temporary storage in Vietnam.

There were significant savings realized through reduction in in-transit loss, damage and pilferage. Reductions in ship recycling times from 10-14 days for break-bulk to 48 hours for containerships significantly increased port capacity, reduced port congestion, and creates the potential for reduced requirements for facilities with widespread containerization. Inherent in containerization is the capability to "throughput" directly from a CONUS supply facility to the ultimate consumer [12, p. 16].

Use of containers during the early stages of a buildup offers the following additional advantages:

- Prestockage and movement of unit equipment.
- Prebinned replacement stocks.
- Temporary storage for material.

--Facilities such as shelters, shop, housing, and command and control centers [12, p. 81].

The JLRB comments that: "The requirement for increased military reliance on containerization is axiomatic," and that: "Integrated supply, distribution, and transportation concepts oriented toward maximum containerization must be developed." [12, p. 82-3].

D. SUMMARY CONCLUSIONS

Based on the Vietnam experience with containers, a number of DOD and service studies were undertaken to explore further the potential for containerization and the problems implicit therein. DOD initiated a Project Master Plan and designated a Project Manager for Surface Container Supported Distribution System in 1973 [13]. This office was subsequently transferred to the Army Material Command. The Army, in The Army in the Field Container System Study (AFCSS), [10], outlined a total container distribution system, including support requirements. The Marine Corps, in the Containerization Requirements for the Fleet Marine Force, 1973-1982, [7], focused on particular circumstances accompanying amphibious landings. The OSDOC tests previously mentioned have been concerned with technical problems of containership off-loading in undeveloped port areas.

The overall conclusion based on the factors so far discussed is that the changing composition of the U.S. merchant fleet, the Vietnam experience and the studies and tests conducted to date is not IF containerization will affect military operations, but WHEN and HOW.

III. MARINE CORPS ORGANIZATION AND ELECTRIC POWER REQUIREMENTS

This section presents a brief description of Fleet Marine Corps missions, units, task organization, and generator support relationships as background for later discussion of possible container applications.

A. THE FLEET MARINE FORCE

The Fleet Marine Force (FMF) is composed of command and control elements and the following major forces:

- Marine Divisions: the primary group combat component.

- Marine Air Wings (MAW): the aviation component.

- Force Troops: specialized combat and support units.

- *--Force Service Support Group (FSSG): the combat service support unit for both group and aviation units.

Units from the above forces are normally assigned to a Marine Air Ground Task Force (MAGTF) on a task basis for a particular mission or period of time. There are three sizes for MAGTF's, each size having ground, aviation, and service support components.

The Marine Amphibious Force (MAF) is the largest MAGTF, and is built around a Marine Division, an Air Wing and an FSSG. Additional support, as required, is provided by Force Troops.

*Note: At this writing the FMF is adopting a new Combat Service Support (CSS) structure based on the FSSG. The FSSG is composed of units formally part of the Force Service Regiment, Marine Division, and Force Troops.

The Marine Amphibious Brigade (MAB) is built around an Infantry Regimental Landing Team (RLT), a composite Air Group, and FSSG detachment, and Force Troops detachments. It is the smallest MAGTF capable of sustained, independent operations.

The Marine Amphibious Unit (MAU) is based on an Infantry Battalion Landing Team (BLT), a composite aviation squadron, an FSSG detachment, and Force Troops detachments.

It should be noted that none of these MAGTF's have fixed structures, and there is considerable flexibility in organization depending upon specific circumstances.

Figures 4, 5, and 6 show the organization of Marine Divisions, MAW, and FSSG. The figures are also annotated as to current mobile electric power support relationships.

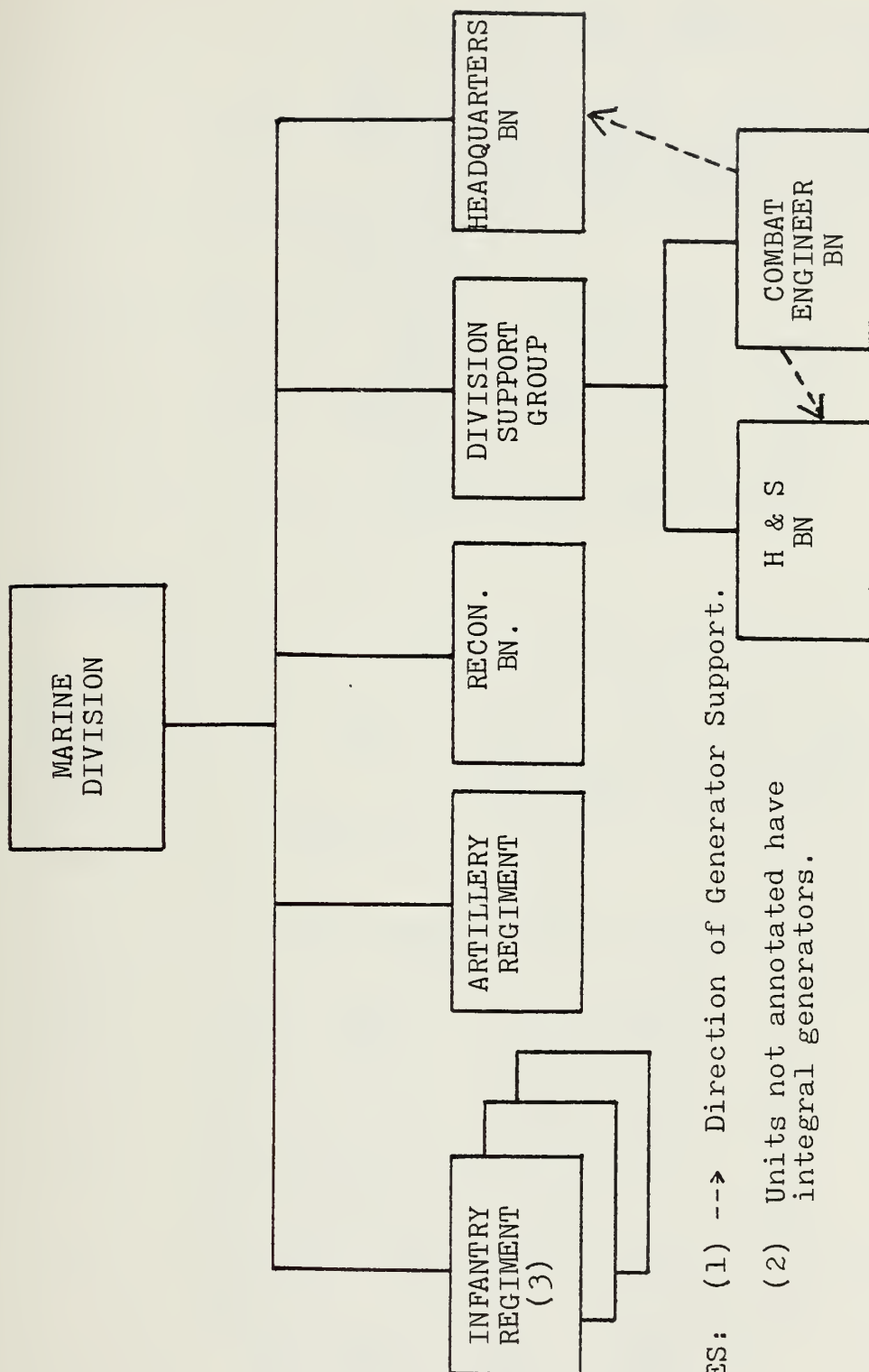
B. ELECTRIC POWER CONSIDERATIONS

Marine Corps Order (MCO) 11310.8B [14], establishes policies applicable to Mobile Electric Power Generating Sources (MEPGS) in the FMF. The salient points relevant to this study are summarized below:

- Only DOD standard MEPGS units, 60 HZ, tactical utility type will be utilized.

- MEPGS are allotted to units on the basis of power-consuming equipment and unit operational considerations, to be used on a "power pool" basis.

- MEPGS will be procured and accounted for in the skid-mounted configuration. Trailers are considered separate end items and will be separately justified and accounted for.



NOTES: (1) --> Direction of Generator Support.

(2) Units not annotated have integral generators.

SOURCES: T/O M1869X, Rev. 9/15/75
MCO 11310.10A (Amended)

Figure 4. Marine Division Organization

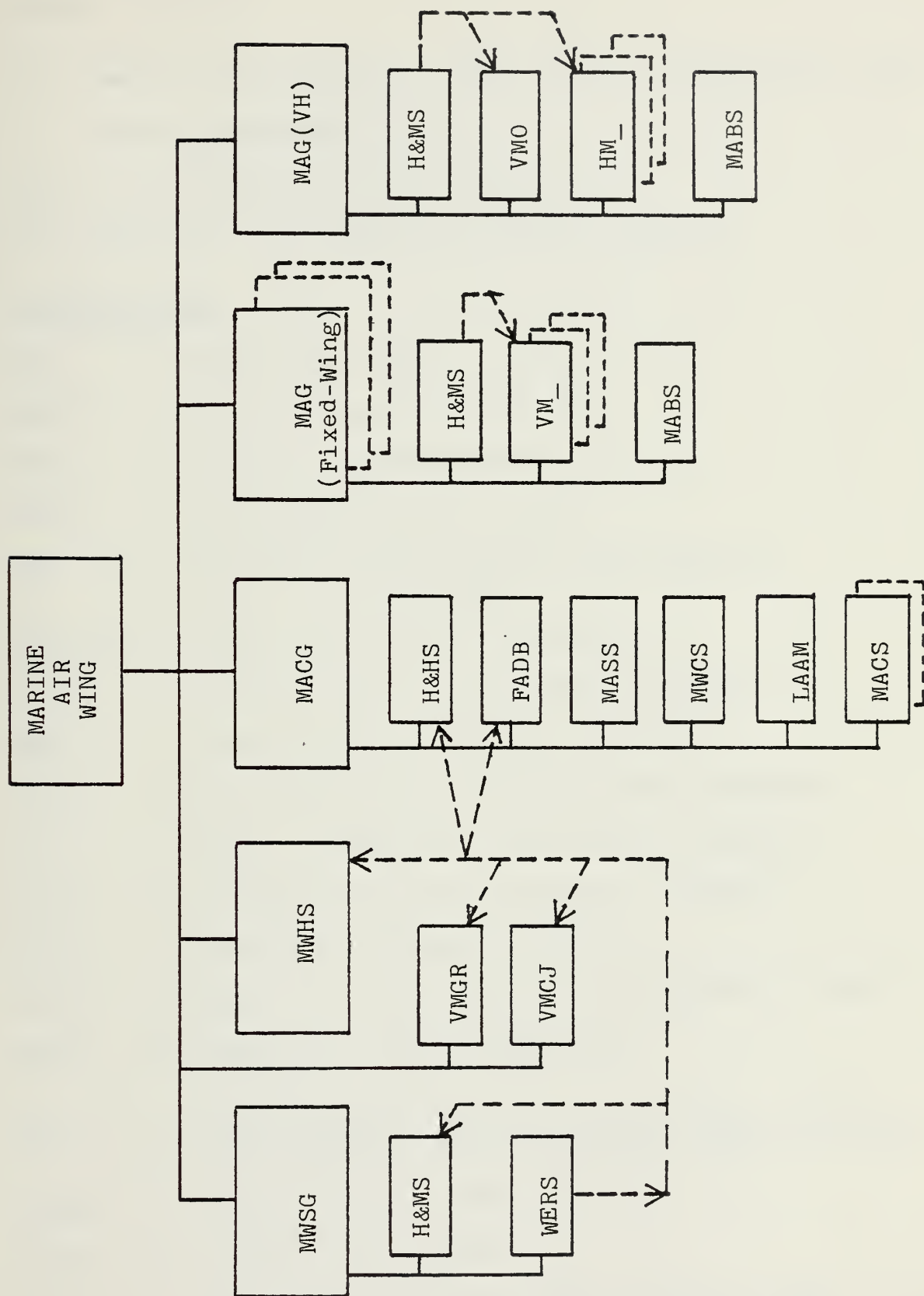


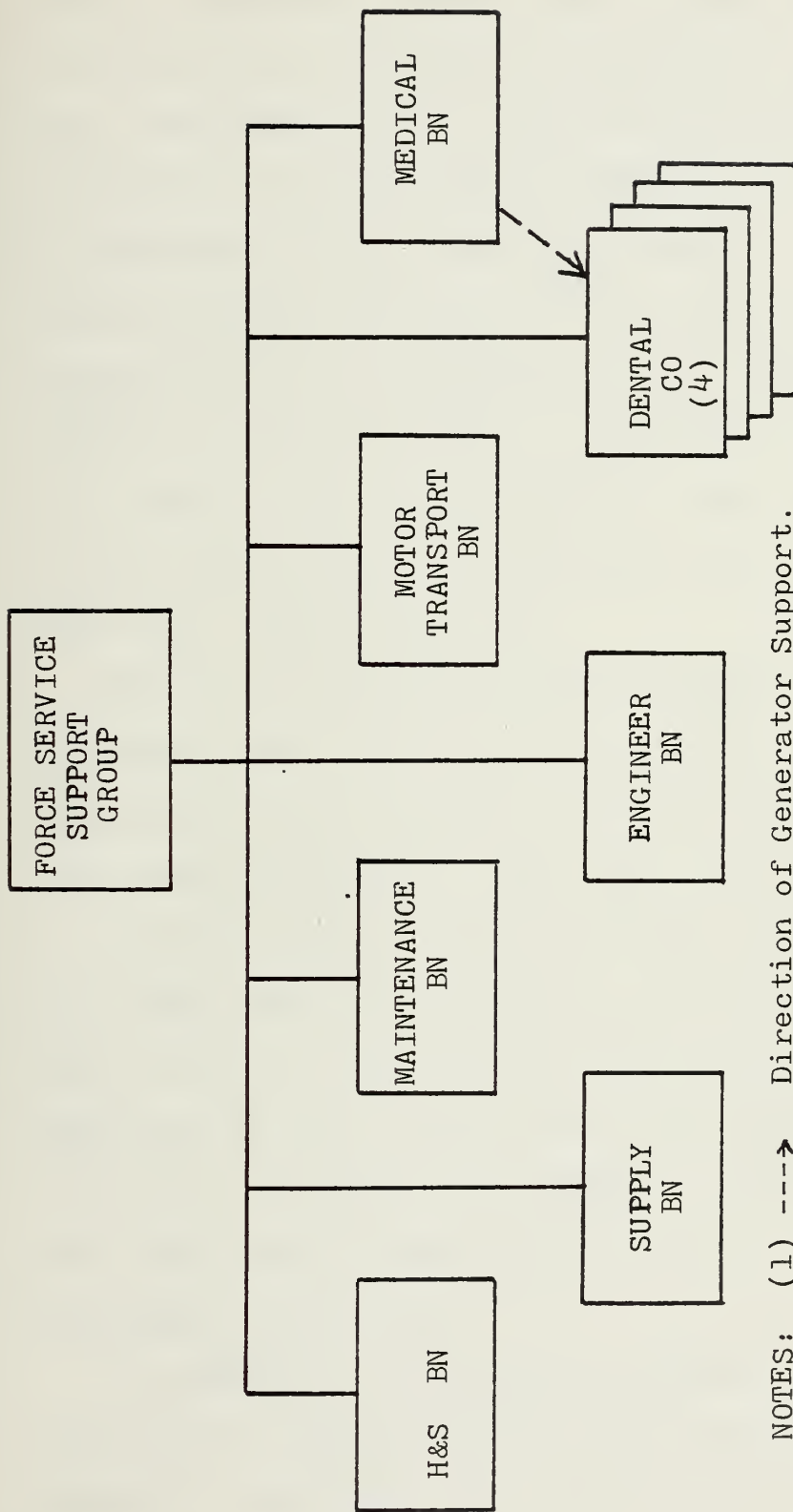
Figure 5. Marine Air Wing Organization (Notes on Following Page)

NOTES (FIGURE 5)

- (1) Marine Air Wings do not have a fixed organization; that shown is representative.
- (2) ----> Direction of generator support.
- (3) Units not annotated have integral support.

ABBREVIATIONS

MAW	=	Marine Air Wing
MWSG	=	Marine Wing Service Group
MWHS	=	Marine Wing Headquarters Squadron
MACG	=	Marine Air Control Group
MAG	=	Marine Air Group (Fixed Wing Aircraft) (One to five per MAW)
MAG(VH)	=	Marine Air Group (Helicopter)
H&MS	=	Headquarters and Maintenance Squadron
WERS	=	Wing Equipment and Repair Squadron
VMGR	=	Marine Aerial Refueler/Transport Squadron
VMCJ	=	Marine Composite Reconnaissance Squadron
FADB	=	Forward Air Defense Battery ("Redeye")
MASS	=	Marine Air Support Squadron
LAAM	=	Light Anti-Aircraft Missile Battalion ("Hawk")
MACS	=	Marine Air Control Squadron (Normally two per MAW)
VM_	=	Fixed-Wing Aircraft Squadron, Attack, Attack (All Weather), Fighter Attack, (One to five per MAG)
MABS	=	Marine Air Base Squadron
VMO	=	Observation Squadron
HM_	=	Helicopter Squadron, Heavy, Medium, Light, or Attack (one to five per MAG VH)
SOURCES:		FMFM 5-1; MCO 11310.10A (Amended)



NOTES: (1) ----> Direction of Generator Support.

(2) Units not annotated have integral generators.

SOURCES: T/O M 3449X, Rev. 3/1/75.
MCO 11310.10A (Amended)

Figure 6. Force Service Support Group Organization

MCO 11310.10A [15] directs consolidation of generator assets, specifies electric power support relationships, establishes T/E allowances by generator type--both immediate and "long range" (i.e., 1980) --and provides detailed descriptions of the DOD standard MEPGS which will be utilized by the Marine Corps. The consolidation, support relationships, and allowances were based on the organizational structure existing prior to establishment of the FSSG. While the specific numbers of generators assigned to units will change as a result of the reorganization, the total power requirements and the total number of generators will not vary significantly under the revised structure.

MCO 11310.10A differentiates between "interim standard generator sets" and "standard generator sets." The interim standard sets are those which are not included in the long range MEPGS structure. The long range structure is planned to include a range of five generator sizes: 3KW, 30KW, 60KW and 200KW, and will be used for the basic data in this study. While there is some variance from types and quantities of MEPGS now in use, the physical characteristics are essentially constant. In addition the MEPGS projected for 1980 coincide well with the projected earliest large-scale introduction of containers in the FMF.

In addition to standardizing MEPGS, the Marine Corps is developing a Modular Expeditionary Power Distribution System (MEPDIS). The MEPDIS will supplant current use of single strand conductors. It will consist of standard lengths of

distribution cable and power panels. The distribution cable will be sized for loads and will have adequate protection to permit shallow burial or placement on top of the ground. Power panels will serve as intermediate and final distribution points to "break down" the power to users. It is contemplated that each unit will have a specific allowance of distribution cable and power panels depending on whether the generators will be dedicated to a single user, or employed in a common user, power pool basis [16].

IV. GENERATORS AND CONTAINERS

The general methodology for considering containerization of generators is outlined in Figure 7. There are three alternatives which will be discussed in order: continue to transport generators as break-bulk cargo; use of containers as a transportation medium only between embarkation-deportation points; and permanent housing of generators in dedicated containers.*

A. GENERATORS AS BREAK-BULK CARGO

This is the technique which has been used to date. More properly, generators are mobile loaded since virtually all are mounted on trailers despite the implied option of skid-mounting in MCO 11310.10A [15, enclosure (1), p. 17].

The most significant advantage of having generators trailer-mounted is the inherent ready mobility. From the ship, where the generator would be located in a vehicle storage area, it can be readily off-loaded for movement to the beach, or directly ashore from pierside berthing, and

*Note: It is generally accepted terminology to refer to a container used primarily as a transportation device as a "container." "Containers" which have as a primary function the permanent housing of some activity, equipment or material are referred to as "shelters." This convention will be observed in this study. Use of either container or shelter will also infer conformance with ISO standards.

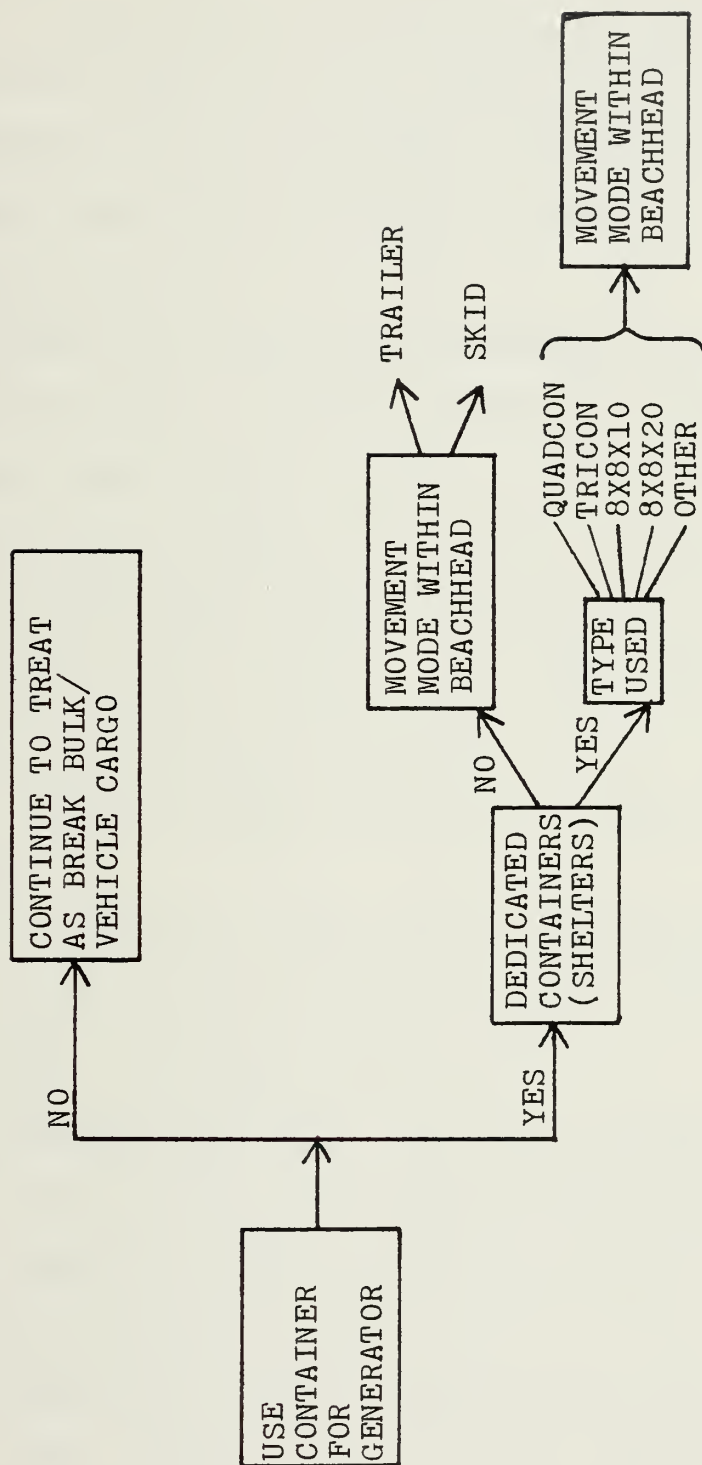


Figure 7. Study Methodology

towed by any prime mover to its utilization point. No special MHE is required for either unloading or for movement. This flexibility is particularly desirable in an amphibious operation since it is not possible to predict exactly when a specific item of equipment will be required ashore. Once ashore, relocation is simply a matter of towing the generator to the new site.

There are several disadvantages with the current procedures. On board ships the trailer-mounted generators take up vehicle storage space, which is very limited. Once ashore, a trailer is required only when the unit is being moved. The larger sized generators (30kW and larger) tend to be associated with activities such as major unit headquarters and maintenance facilities which are relatively static. In these instances they serve no useful purposes for long periods between relocations.

It should be noted that the 200kW generators, when placed in service, will be used in the skid-mounted configuration only [17, Enclosure (3), p. 27].

Although generator units are designed to operate in the open with no other environmental protection than their housing, sheds are almost invariably constructed over them. Sheds or lean-to's provide additional protection from sun, wind and sand, thereby reducing maintenance and breakdown. They also help to ensure that the generator and the connections between the generator and the distribution system are at least partially protected from inclement weather.

There are no formal decision rules for when sheds should be constructed, but the applicable Army Technical Manual states that: "Such (temporary) shelters as lean-to, shack, or shed will be sufficient to house the generator plants," implying that such protection is desirable [17, p. 3-8].

The electrical distribution materials required, such as bulk wire, insulators, and wiring harnesses are packed and loaded separately from the generator. With trailer-mounted generators the MEPDIS material would likewise have to be handled as a separate item.

B. USE OF CONTAINERS AS TRANSPORTATION MEDIUM ONLY

This section will consider the compatibility of various standard sizes of containers with the Marine Corps generators included in the long-range MEPPS plan. Loading of generators in both trailer-mounted and skid-mounted configurations will be simulated.

Figure 8 gives the dimension and weight parameters of generators, trailers and generator-trailer combinations which were used. Figure 9 gives similar data on the containers used, and Figure 10 shows outline sketches of these containers arranged in twenty-foot configurations.

Containers were selected for evaluation on the basis of the following criteria:

--Are in use commercially or are modifications thereof in the case of Quadcon (MC) and Tricon (MC). Additionally, are in use or are being considered for use by the military.

GENERATORS(1)		CORRESPONDING TRAILERS		GENERATOR/TRAILER COMBINATION
GEN.	GEN. SIZE L X W X H WT. (Pounds)	TRAILER MODEL	SIZE(inches) L X W X H (2) WT. (Pounds)	GEN. ON TRLR. L X W X H (inches) Wt. (Pounds)
3kW	35X25X25 285	M762	112X61X28 570	112X61X53 1140 (2 gen./trlr.)
30kW	80X36X57 3500	M200A1 (3)	162X93X38 2410	162X93X95 5910
60kW	87X36X59 5000	M200A1 (3)	162X93X38 2410	162X93X97 7210
100kW	106X40X65 7866	M353	188X96X28 2500	188X96X93 10,366
200kW	114X50X75 12,594	N/A	Skid-mounted only	114X50X75 12,594

NOTES: (1) All generators in the skid-mounted configuration are transportable by five ton truck, C130 aircraft, and CH 53D helicopter [15, Encl. (1), p. 17.

(2) Height is to bed of trailer, not maximum height.

(3) M 353 Trailer may also be used.

SOURCES: MCO 11310.10A
 Department of the Army Technical Manual 9-500
 Department of the Army Technical Manual 9-2330-251-14
 Department of the Army Technical Manual 5-6115-465-12
 Department of the Army Technical Manual 5-6115-545-12
 Department of the Army Technical Manual 5-6115-457-12
 Department of the Army Technical Manual 5-6115-458-12

Figure 8. Generator and Trailer Characteristics

CONTAINER	OUTSIDE DIMENS. NOMINAL(inches) H X W X L	INSIDE DIMENS. (inches) (1) H X W X L	MAX. GROSS WEIGHT (pounds)
QUADCON	96X96X60	$86\frac{1}{2} \times 90\frac{1}{2} \times 50\frac{1}{8}$	10,000
QUADCON (USMC) (2)	82X96X57.5	$72\frac{1}{2} \times 90\frac{1}{2} \times 50\frac{1}{8}$	10,000
TRICON	96X96X80	$86\frac{1}{2} \times 90\frac{1}{2} \times 70$	14,933
TRICON (USMC) (2)	82X96X77.5	$72\frac{1}{2} \times 90\frac{1}{2} \times 70$	14,933
DEMI-CON	96X96X118	$86\frac{1}{2} \times 90\frac{1}{2} \times 110$	22,400
8X8X20	96X96X240	$86\frac{1}{2} \times 90\frac{1}{2} \times 231$	44,800
FLATRACK	96X96X240	N/A	45,000

NOTES: (1) Door dimensions typically 2"-4" less than inside height, width, depending on manufacturer.

(2) Quadcon (MC) and Tricon (MC) are conceptual containers with a reduced height to meet overhead clearance constraints on amphibious shipping [7, p. 117].

SOURCES: ISO Recommendation R668, October 1970.
Quadcon (MC) and Tricon (MC) only, [7, p. 117].

Figure 9. Container Characteristics

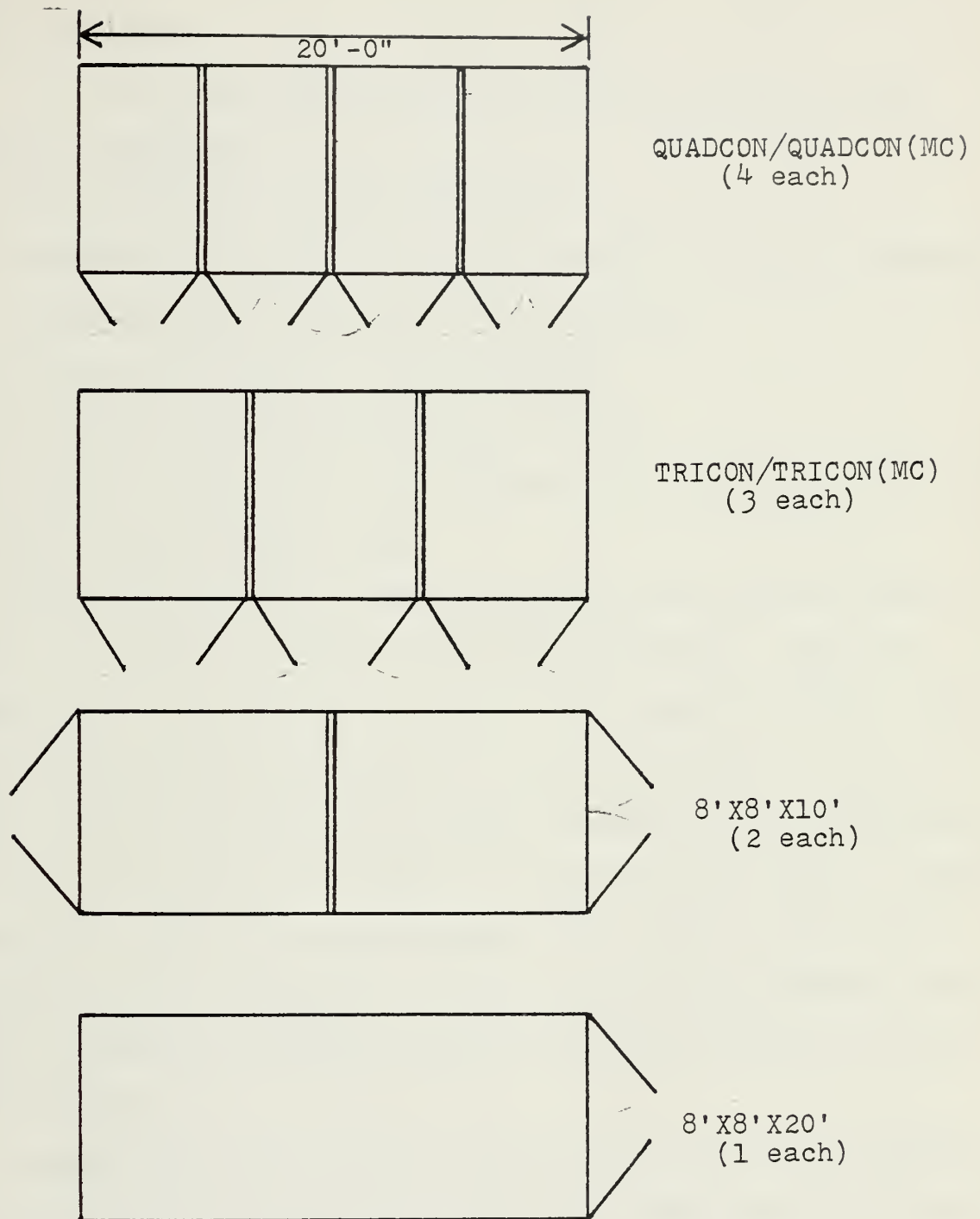


Figure 10. Top(Plan) View of Standard Containers Arrayed in 20-Foot Configuration

--Can be joined to form 20-foot modules compatible with ISO standards.

--Do not create requirement for MHE in excess of those for ISO containers.

The criteria for evaluation were:

--Physical constraints: Will the unit fit in the container?

--Gross weight limits for the container.

--Cube utilization of the container.

--Unique stuffing/stripping problems.

Figure 11 summarizes the results of the loading simulations for skid-mounted generators.

The simulations for trailer-mounted units are not shown since the results were uniformly disappointing. The only combination which would fit inside a dry cargo container was the double-mounted 3kW units on the M 762 trailer, two of which could be loaded in an 8X8X20 container or on a flatrack. All the other generators were too large to fit inside a closed container, and, more surprisingly, were even too high to be accommodated on a flatrack. Thus, the use of containers with trailer-mounted generators can be virtually eliminated from consideration.

Transporting skid-mounted generators in containers appears to be a feasible alternative. The only significant problem is when the long axes of the generator and the container coincide. In these situations normal forklift equipment will not be able to stuff/strip the load. This will require the use of rollers

GEN	QUADCON	QUADCON MC	TRICON	TRICON MC	8X8X10	8X8X20	FLATRACK
<u>3kW</u>							
QUANTITY	4/8(a)	4/8	6/12	6/12	9/18	18/36	N/A
CUBE UTIL.	.20/.40	.24/.48	.22/.45	.27/.53	.24/.48	.23/.45	N/A
CARGO WT	1140/2280	1140/2280	1710/3420	1710/3420	2565/5130	5130/10,260	N/A
<u>30kW</u>							
QUANTITY	1	1	1	1	3	6	6
CUBE UTIL.	.37	.44	.27	.32	.58	.55	N/A
CARGO WT	3500	3500	3500	3500	10,500	21,000	21,000
<u>60kW</u>							
QUANTITY	1	1	1	1	3	6	6
CUBE UTIL.	.41	.50	.31	.36	.66	.62	N/A
CARGO WT	5000	5000	5000	5000	15,000	30,000	30,000
<u>100kW</u>							
QUANTITY	(c)	(c)	(c)	(c)	2(b)	4(b)	4
CUBE UTIL.					.65	.62	N/A
CARGO WT					15,732	31,464	31,464
<u>200kW</u>							
QUANTITY	(c)	(c)	(c)	(c)	(c)	2(b)	2
CUBE UTIL.						.48	N/A
CARGO WT						25,188	25,188

- NOTES: (a) Upper figure for single tier, lower figure when removable horizontal platform is used.
- (b) Stuffing/stripping problem due to coincidence of long generator dimension that of container.
- (c) Generator will not fit container.

Figure 11. Results Containers and Generators (Skid-Mounted)

or air pallet techniques. These techniques may also be required for 30 and 60kW generators, depending on the MHE available.

Tie-downs, anchors, and chocking are required to prevent movement of these generators during transit. In the case of flatracks, additional environmental protection such as tarpaulins or polyethylene sheeting is required to prevent salt water damage during transit.

As expected with heavy items of equipment, cube utilization is not particularly good, although for the larger sized containers (i.e., 8X8X10 and 8X8X20) it is 50 percent or greater. Weight limits of the containers are not exceeded with any combination.

The most significant problem with this alternative is that the generators are skid-mounted, and the inherent mobility noted in the previous section is forfeited with no compensating gain after the destination is reached. (Note: 200kW will always be skid-mounted.) The generator would have to be either remounted on trailers which had been transported separately or be moved in the skid-mounted configuration, which would require MHE activity at both ends. There will also be the implicit requirement for sheds discussed in the previous section.

It should also be noted that MEPDIS components associated with generators were not loaded in the same container. This equipment would have to be loaded and transported separately.

C. USE OF SHELTERS

The permanent housing of generators in dedicated containers--shelters-- is the last alternative to be considered. The intention is to provide in a single "package" all that is required for power generation and distribution. With this configuration it must be assumed that generator shelters would be in an environment where a significant portion of the landing forces' other assets would be in containers and shelters. This would further imply that off-loading equipment and MHE to handle large numbers of containers would be available in the landing area. These considerations are addressed further in Section V.

The shelters considered for use were selected using the same criteria listed in the preceding section--Containers Used as a Transportation Medium Only. The major exception is that these shelters are conceptual modifications of standard containers rather than being ones actually in use. Areas of evaluation can be separated into two categories: The shelter as a transportation medium, and the shelter as a structure for housing operating generators.

In the first category (i.e., transportation medium) the following factors are relevant:

- Physical capacity for generators, MEPDIS (panels and distribution wire) and jack supports.
- Structural requirements/limits.
- MHE requirements.

In the area of generator operations the following are relevant:

- Exhaust/ventilation requirements.
- Fueling and servicing access.
- Anchoring and vibration.
- Fire protection.

Figure 12 summarizes the possible combinations of 10 and 20 foot shelters with 30kW, 60kW, 100kW and 200kW generators and associated MEPDIS. All weights are well within limits for the shelter size.

When the generators are fitted into various shelters it becomes readily apparent that only the larger-sized configurations--10-foot and 20-foot--are adequate.

While there are no fixed requirements for access space around generators, there must be sufficient room for panels to be swung open. This requirement was taken as the minimum side clearance required. Panels which would normally be required for outside protection when generators are not in use (radiator and control panel covers) were considered to have been removed.

Two basic methods of entry to the shelter were considered. In the first, standard dry cargo container doors were put in both ends of the shelter. This would permit airflow/ventilation and would represent a relatively minor modification to a standard item. The second approach was to utilize a specially manufactured shelter with upswinging side panels and personnel doors in each end. This is modeled after TACOSS VII, described below.

GENERATOR SIZE(1)	SHELTER CHARACTER	NUMBER GENERATORS	SIDE CLEAR.	END CLEAR.	OVERH. CLEAR.	NET WEIGHT	REMARKS
30kW	10'						
	END DOORS	1	27	15	29	4,595	
	SIDE DOORS	1	27	5(2)	29	4,595	
	20'						
	END DOORS	2	27	51	29	9,190	See Note (3)
	SIDE DOORS	3	30	5(2)	29	13,285	
60kW	10'						
	END DOORS	1	27	11	27	6,440	
	SIDE DOORS	1	27	11(2)	27	6,440	
	20'						
	END DOORS	2	27	50	27	12,880	See Note (3)
	SIDE DOORS	3	30	2(2)	27	19,320	
100kW	10'						
	END DOORS	1	25	2	21	9,801	
	SIDE DOORS	1	25	2(2)	21	9,801	
	20'						
	END DOORS	2	25	15	21	19,602	See Note (3)
	SIDE DOORS	2	25	15	21	19,602	See Note (3)

Figure 12. Results Shelters and Generators

Figure 12 (Continued)

GENERATOR SIZE(1)	SHELTER CHARACTER	NUMBER GENERATORS	SIDE CLEAR.	END CLEAR.	OVERH. CLEAR.	NET WEIGHT	REMARKS
200kW	10'						
	END DOORS	1	20	(4)*	11	15,714	* Must reduce
	SIDE DOORS	--(4)	--	---	--	-----	generator
	20'						length by four
	END DOORS	1	20	58	11	15,714	inches. insuf-
	SIDE DOORS	1	20	58	11	15,714	ficient room for
							MEPDIS.

NOTES: (1) Only 30kW and larger generators considered.
 (2) Sufficient end clearance when shelter sides raised.
 (3) Generators end to end, possible problems with airflow/ventilator.
 (4) Generator does not fit; insufficient end clearance.

There are at least two systems in being which operate generators within a shelter. These units will be described in order to indicate the feasibility of such operations and to discuss potential problem areas.

The USAF Bare Base program is designed to provide modular facilities rapidly in an advanced theater of operations. The primary electrical power unit for Bare Base is a 750kW gas turbine engine-driven generator. It is enclosed in a shelter fitted with louvered panels for ventilation/cooling. Each unit is mounted on a four-wheel, swing-axle trailer chassis. Overall dimensions are 241"X96"X99" (LXWXH), and the total unit weight is approximately 20,000 pounds. A modular electric distribution system is also included in the unit. It is transportable by C-130 aircraft, but is not compatible with ISO standards.

The Air Force is currently operating eight of these units in Alaska and has had generally excellent results [18].

The U.S. Navy Civil Engineer Corps has developed a family of modular shelters suitable for rapid deployment to under-developed areas called TACOSS (Tactical Container Shelter System). The TACOSS provides modules for living, messing, administration, sanitation, shops and utilities. All modules are compatible with ISO 20-foot container standards. (See Figure 13)

The utilities module, TACOSS VII, houses two diesel engine driven 60kW generators, electrical distribution equipment, and water purification equipment. The module weighs

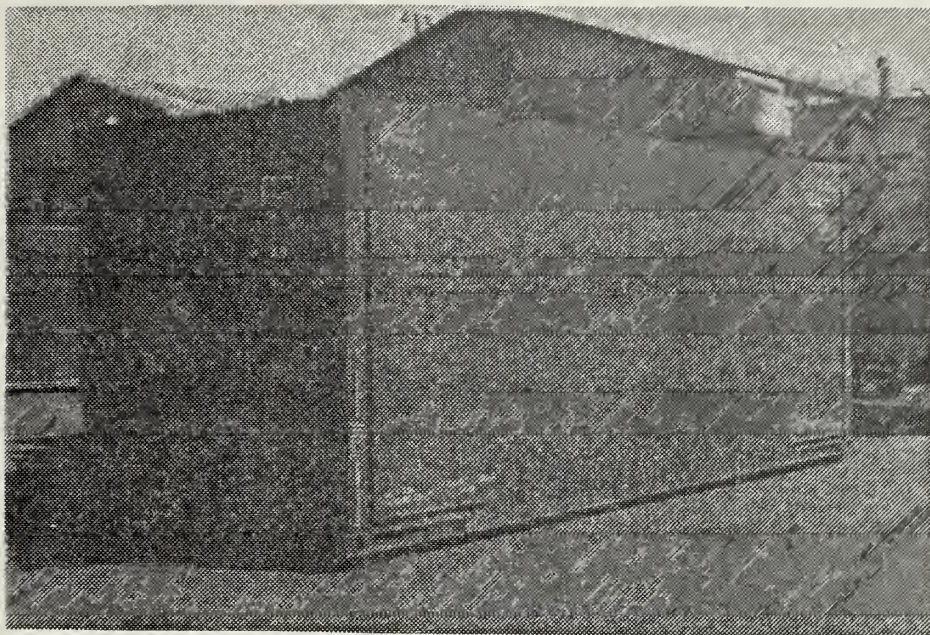


Figure 13. 20-Foot TACOSS Shelter in Transportation Configuration

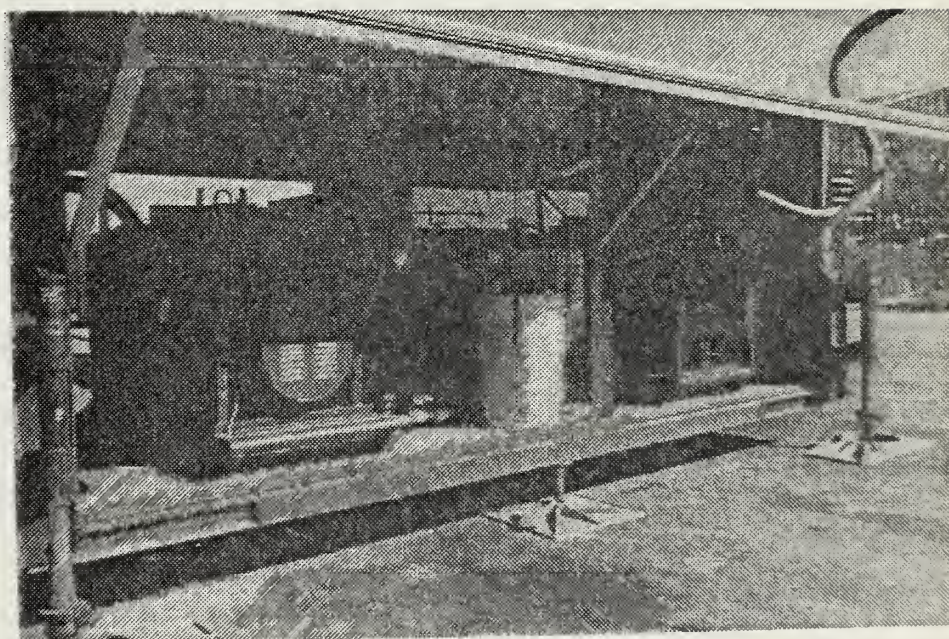


Figure 14. TACOSS Generator Shelter in Operational Configuration
Note: Leveling Jacks, Open Side Panels, and Exhaust Pipe

approximately 17,000 pounds. Access to TACOSS VII is through personnel doors at each end. When the generators are being operated, both side panels, which are hinged at the top, are swung open and supported with a bracing system. (See Figure 14)

The side panel arrangement permits adequate ventilation and cooling as well as access to the units. Panels can be lowered incrementally as required during inclement weather.

The unit has a structural steel frame, standard ISO corner fittings, and panels of aluminum and honeycomb. Another prototype is under construction, utilizing fiberglass-reinforced plywood (FRP), which appears to be a satisfactory material, also. The floor system is reinforced at generator mounting points to carry the weight of the generators.

Exhaust is removed by means of flexible metal hose run out the side openings. Fuel tanks integral to the generators are filled as needed, although an exterior auxiliary fuel system (55 gallon drums) could be used. Standard generator mountings are sufficient to preclude excessive vibration.

Jacks at each corner level the module, and intermediate ground supports are located on each side of the module. CO₂ extinguishers provide fire protection. The modules are handled as heavy cargo, and cranes are utilized in lieu of other MHE [19].

Since procurement in 1973, the unit has been used successfully on three deployments with very satisfactory results.

D. SUMMARY CONCLUSIONS

--Maximum flexibility and mobility is achieved by retaining 100kW and smaller generators in trailer-mounted configurations.

--Provisions to handle 200kW generators in the skid-mounted configuration must be made.

--Although not specifically required, temporary shelters (sheds) are almost invariably constructed over generators during field operations.

--It is not feasible to load trailer-mounted generators in dry cargo containers or flatracks.

--Skid-mounted generators can be loaded in dry cargo containers and flatracks, but only by sacrificing ready mobility at the destination.

The experience with and success of the TACOSS VII is strong evidence for the practicality of operating generators within ISO configured shelters. It is reasonable therefore to conclude that any of the configurations contained in Table VI would be acceptable operationally as well as meeting transportation requirements.

V. GENERATORS AND SHELTERS

The initial sections of this study have established that containerization will have a significant, if not a dominant, influence on the logistical support of future military operations. The preceeding section concludes that operating generators can be shelterized. This section will discuss the extent to which generators should be shelterized. The primary constraints to be considered are Marine Corps organization and the operational requirements of deployed forces. The focus will be on the Marine Corps' primary mission, that is, the conduct of amphibious operations.

A. ORGANIZATIONAL AND MISSION CONSIDERATIONS

As noted previously, any program for containerization/sheltering of generators must be predicated on the adoption by the Marine Corps of a containerization system for a large portion of a landing force's assets. This, in turn, implies that an OSDOC scheme is perfected and that onshore MHE and transportation equipment are provided.

The source of the most detailed containerization concept for the Marine Corps is, at this time, Containerization Requirements for the Fleet Marine Force (1973-1982), (Reference 7 hereafter, the "Container Study"). This study has been approved by HQMC for planning purposes [16]. The Container Study's salient recommendations and conclusions are summarized here for convenience.

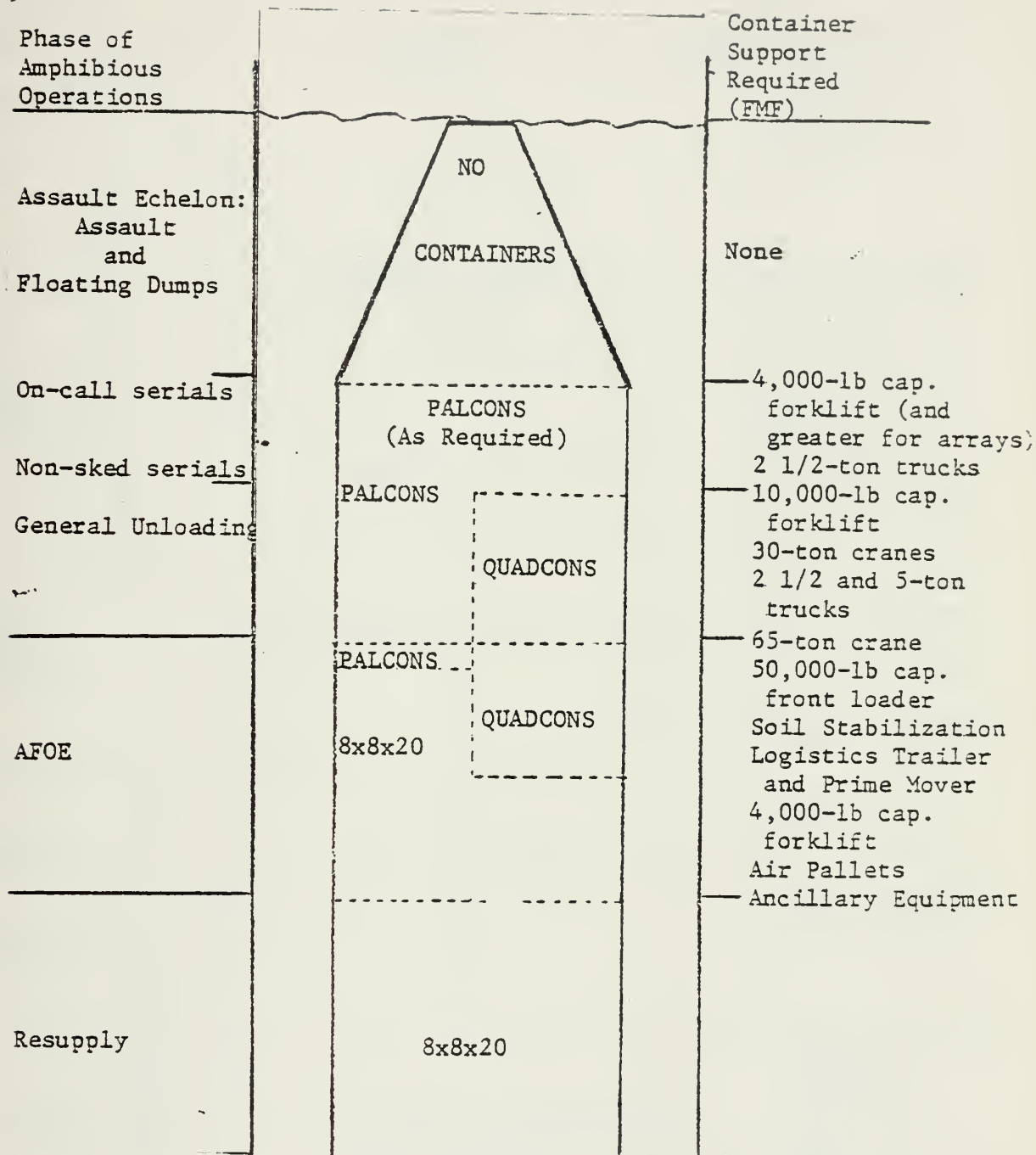
The landing force will employ three sizes of containers: PALCON*, QUADCON(MC), and 8X8X20. As depicted in Figure 15, the assault echelon would carry no containers. As the build-up ashore progresses, PALCONS and QUADCONS would be phased ashore. The assault follow on echelon (AFOE) would have all three sizes, while resupply would be based around the 8X8X20. Figure 15 also lists the container support equipment and material required.

The various possible MAGTF (See Section IIIA) would have an influence on the size of container used. The MAU would employ only PALCONS and QUADCONS. The MAB adds 8X8X20's, but only for force resupply and retrograde. The MAF would use QUADCONS and 8X8X20's, commencing with the AFOE, as well as the 8X8X20 for force resupply and retrograde.

Figure 16 outlines container operations once the landing force is established ashore. The support requirements are again listed. It should be noted that neither QUADCONS nor 8X8X20's are moved forward of the logistic support areas (LSA), which are the primary sources for resupply and maintenance support of the landing force [7, p. 52-58].

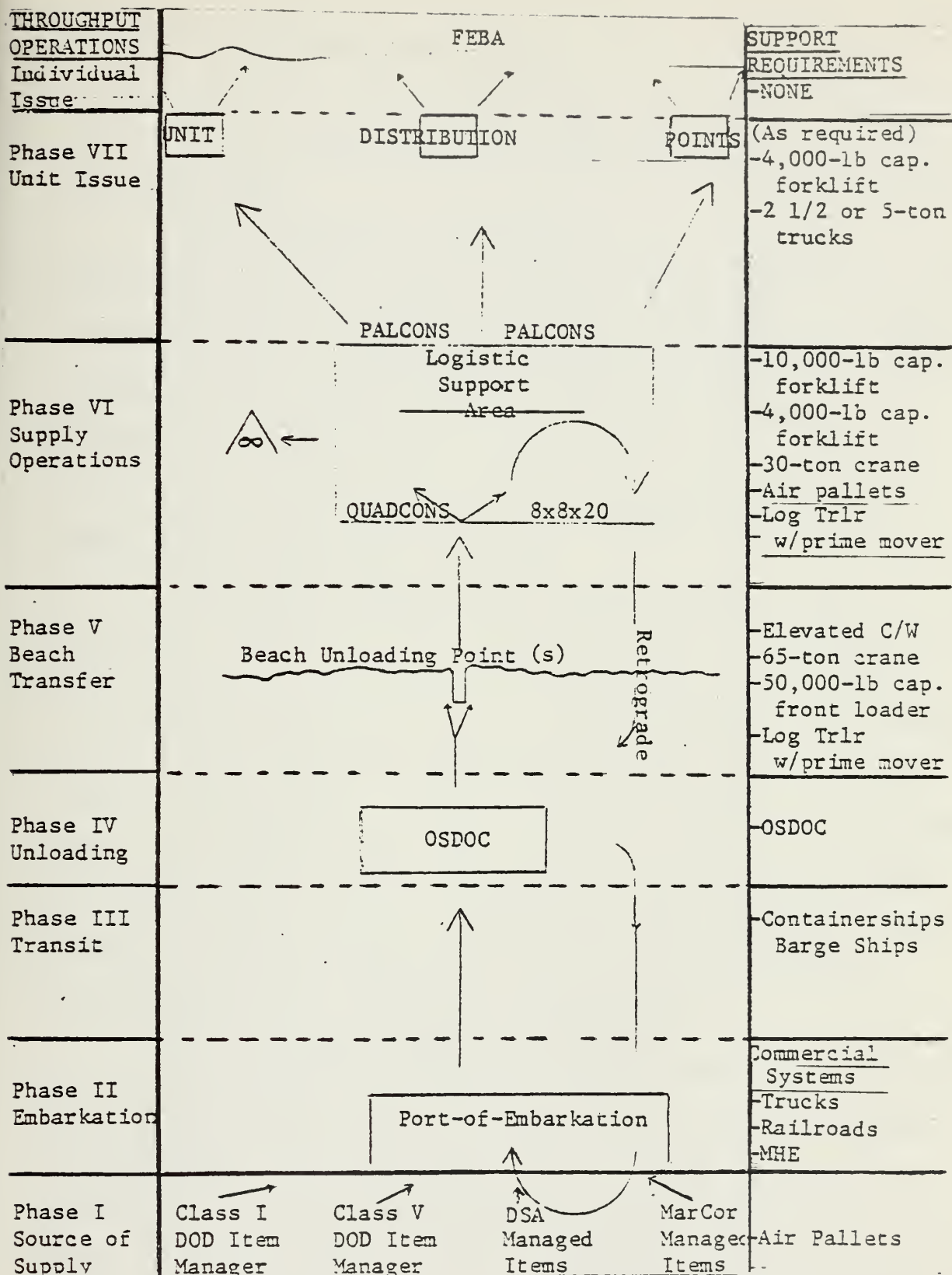
The preceding summary serves as a reference frame for a discussion of the multifarious functional and task organizations which must be accommodated by the logistic support system in general, and generator support in particular.

* PALCON is a conceptual container, 40"X48"X41" (LXWXH), which could be used individually or arrayed in increments up to an ISO compatible module 8'X6'10"X20'. Development work is currently underway [7, p. D-1].



SOURCE: Containerization Requirements for the Fleet Marine Force (1973-1982), p. 57 [77].

Figure 15. Container Employment for Amphibious Assault Operations



SOURCE: Containerization Requirements for the Fleet Marine Force (1973-1982), p. 58 [7].

Figure 16. Subsequent Operations Ashore

1. Functional Organization

The functional organization of Divisions, Wings, and Force Service Support Groups (FSSG) separates units by major mission areas.

The Division, as the major ground combat unit, must have ready tactical mobility and the flexibility to support widely scattered subordinate units and detachments. Ground elements will invariably be the first ashore and are responsible for expanding the beach head. Individual unit electrical power requirements are generally relatively small and at scattered locations.

Wing units operate from established or expeditionary airfields, phasing ashore after the initial beach head has been secured by ground forces. Aircraft support and command/control requirements are considerably more elaborate than those of the division. Unit electrical demands are typically large and concentrated. Once ashore, aviation units enjoy a wide operating radius in support of ground forces. Consequently, the requirement for mobility is more related to administrative than tactical considerations.

As the primary logistics support agency for the landing force the FSSG is a very large unit, containing upwards of 10,000 men. As is the case with the Wing, it will be phased ashore after ground forces initially secure the beach head. The major portion can be expected to remain relatively static, although there will be requirements to provide detachments for support of widely scattered ground units. Its

maintenance and supply functions are large users of electrical power.

Within the functional organization, ground units are designated as combat, combat support (CS) or combat services support units (CSS). The combat units, for example, an infantry regiment or a reconnaissance battalion, have inherent tactical mobility requirements, and consequently have a minimum of logistics related assets.

Combat support units, a division engineer battalion, for example, provide direct support to combat units. This support must have essentially the same mobility capabilities as the combat unit being supported. Combat support units also provide more general support to large functional organizations, and this support requires considerably less mobility.

Combat service support units provide the primary logistic backbone of the landing force and are located in the FSSG. The CSS units have large quantities of maintenance assets and supply material, and normally provide support from relatively stable locations.

It must also be realized that each Marine Air Ground Task Force (MAGTF) incorporates a "slice" from these CS and CSS units. The mobility and support needs of the MAU or MAB in particular dictate those required by their CS and CSS components. Put another way, the CS and CSS cannot be looked upon as autonomous entities, but must be considered in terms of their support missions for combat units.

A further complication is that many CS and CSS units provide generator support to other components within the functional organization. Figures 4, 5 and 6 (Section III.A.) illustrate these habitual relationships. Even in static situations these CS and CSS units must have the flexibility to rapidly relocate generator assets to meet changing demands and unit relocations and to effect maintenance.

2. Task Organization

The MAGTF configurations, MAF, MAB, and MAU, cut across functional organization lines. The MAF would include an entire division, a wing and an FSSG, while the MAB and MAU would typically be composed of one-third and one-ninth respectively of the three basic functional units [20, p. 9-11].

The circumstances attendant on the establishment of a MAGTF will vary, thereby requiring that there be sufficient flexibility in organization to permit tailoring of each MAGTF. This flexibility is also required in the provision of electrical support, particularly with the MAB and MAU. The relatively small size of the MAB and MAU places a premium on simplicity in the range of equipment and logistic support provided.

3. Logistics Support for Landing

In conducting an amphibious landing, supplies can be divided into two categories, assault supplies and resupply. The assault supplies are "those supplies loaded in assault shipping which provide the required initial supply support for the landing and associated operations" [21, p. 67].

Assault supplies can be further broken down into prescribed loads, which can be described as those items carried by individuals and pieces of equipment, and landing force supplies.

Landing force supplies are, in turn, composed of floating dumps from which initial resupplies are made and remaining supplies which constitute the bulk of the landing force's supplies carried in the assault shipping. Remaining supplies are landed during the general unloading phase of the amphibious operation.

Resupply encompasses supplies transported to the objective area to maintain necessary supply levels [21, p. 67-69].

The Container Study recommends that prescribed loads and floating dumps not be containerized, while remaining supplies and resupply should be containerized [7, p. M-21]. Generators would fall almost exclusively in the remaining supplies category.

4. Shipping Organization

The landing force can be loaded aboard three types of shipping: Navy amphibious ships, MSC ships, and commercial (break-bulk and/or container) ships. While the assault echelon would normally be transported in amphibious ships, it can be reasonably anticipated that at least a portion of the AFOE and the preponderance of resupply requirements will be moved via MSC and commercial shipping.

Supplies and organic equipment for each landing organization must be compatible with the type of shipping actually provided. However, in a particular operation, deficiencies in amphibious shipping would have to be made up from the other two sources, and conversely, portions of the AFOE might well go in amphibious shipping dependent on availability.

Typically, shipping availability is not known until a short time prior to embarkation. Consequently the containerization system adopted must be amenable to any or a mixture of the indicated shipping types.

B. DISCUSSION OF CRITERIA FOR SHELTERIZATION OF GENERATORS

Based on the preceding discussion, general criteria for selecting candidate generators for shelterization can be enumerated. The intent is not to select specific generators which should be shelterized--the lack of specific tables of equipment at this time by itself precludes such an effort--but to identify the units and generators by size classification which are potential candidates.

The limited scope of this evaluation is further justified in light of:

- the still tentative nature of the containerization system to be adopted by the Marine Corps.

- the recent FSSG restructuring and possible modifications thereto.

- potential further reorganization such as envisioned by the "Haynes Board" [22, p. 47.

--possible adoption of the "Shelter Study" (See Section V. D. 1).

The relevant criteria for shelterization are summarized as follows:

--Shelterization must be consistent with unit missions and organization. Organization includes functional, task, landing, shipping and support dimensions.

--Units which provide significant generator support to other units must retain at least a portion of their generators trailer mounted. This will permit flexibility in accommodating unit relocations and meeting maintenance requirements.

--Larger sized generators--100kW and 200kW--are more attractive candidates for shelterization than smaller sizes. These units are assigned only to units with large, concentrated power users and relatively stable missions and locations. The smaller units are more readily mobile and can be "paralleled"* to provide the quantities of power required at remote locations and to support MAU and MAB deployments. In effect, smaller sized generators can provide required operational and organizational flexibility.

*Parallelling is the connecting of two or more generators so that the total power output available for input into a single distribution system is the sum of the individual generators. All Marine Corps generators other than the 3kW unit are capable of parallel operation / 15, Enclosure (1); 17, p. 50-527.

--Generators must have mobility commensurate with that of the unit or function being supported. A unit should not be burdened with unique logistic and mobility constraints imposed only by shelterized generators. A unit already having modularized/shelterized functions presumably has a relatively static role or has the means to relocate its assets if necessary. As noted previously, the Container Study envisions intermediate and large sized containers not being advanced beyond the LSA's. Implementation of generator shelterization would therefore require use of existing MHE and transportation assets for units not co-located with the LSA.

C. DISCUSSION OF GENERATOR SHELTERIZATION BY UNIT

Figure 17 shows the sizes of generators which are anticipated to be in units under the "long range" MEPGS plan. Numbers of generators by unit are not available at this time, but estimated total numbers by size for the entire FMF are shown.

Considering Figure 17, and Figures 4, 5, and 6 (functional organization and generator support relationships), and the preceding discussion on unit organization, unit missions, and shelterizing criteria, it is possible to draw some conclusions regarding the advisability of containerizing generators of a particular unit and to select candidates for shelterization.

UNIT	3kW	30kW	60kW	100kW	200kW	REMARKS
<u>DIVISION</u>						
INFT. RGT.	X	X	X	--	--	
ARTY. RGT.	X	X	X	X	--	
RECON. BN.	X	X	--	--	--	
DSG	X	X	X	X	--	Supports HQ Battalion
<u>WING (See Figure 5 for Abbreviations)</u>						
<u>MWSG</u>						
WERS	--	X	X	X	X	Supports: H&MS, MWSG; UMGR; UMCJ; MWHS; H&HS, FAADB MACG.
<u>MACG</u>						
MASS	--	--	X	X	X	
MWCS	--	X	X	--	X	
MACS	--	--	--	--	X	
LAAM BN.	--	--	--	X	X	
<u>MAG (HELO/FIXED WING)</u>						
H&MS	--	X	--	X	X	Supports all organic flying squadrons.
MABS	--	X	--	X	X	
<u>FSSG</u>						
H&S BN.	X	X	X	X	X	
SUPPLY BN.	--	--	--	X	X	
MAINT BN.	--	X	X	X	X	
ENGR.SPT.BN.	--	X	X	--	X	
MOT. TRANS.BN.	--	X	X	--	--	
MED. BN.	--	X	X	--	X	Supports dental companies.
	175	283	167	330	192	Estimated FMF total by type in "long range" generator plan
SOURCES: MCO 11310.10A (AMMENDED)						
FMF TABLE OF ORGANIZATION M3449x (FSSG)						
M1869x (DSG)						
HQMC (CODE LME-2) APRIL 1976						

Figure 17. Generator Size by Unit

1. Marine Division (Figure 4)

In the Marine Division two of the four units possessing generators are combat units: the Infantry Regiment and the Reconnaissance Battalion. The Artillery Regiment, while classed as a combat support unit, has mobility requirements very similar to those of the combat units. Accordingly, none of these units is a candidate for shelterization.

The Division Support Group (DSG) is a combat support unit. It provides generator support for the Division Headquarters Battalion, which includes the command and control elements. While the Headquarters Battalion and the DSG would tend to remain relatively static, there remains the requirement for internal flexibility in providing generator support. Accordingly, DSG generators should remain trailer-mounted.

The conclusion to leave all division generators trailer-mounted is further reinforced by the absence of any 200kW (i.e., skid-mounted) generators in the division.

2. Marine Air Wing (Figure 5)

The Marine Air Wing organizational and generator relationships are considerably more complicated than those of the division.

a. Marine Wing Service Group (MWSG)

The Wing Equipment and Repair Squadron (WERS) in the Marine Wing Service Group (MWSG) provides generator support for as many as six external units. It is, in effect, a generator pool for a number of large users, in particular

the Marine Wing Headquarters Squadron (MWHS), which includes the Wing command and control elements. Here, as with the DSG, there is an inherent requirement for mobility in meeting internal relocation and in being responsive to changing electrical demands. However, the Wing, once established ashore, can perform its missions over a wide area from a single location. Accordingly, the need for full unit mobility is considerably less than that of the division. The inclusion of 200kW generators is a further factor. The command elements of the MWHS and the maintenance/support functions of the MWSG will be the major users of power from the large generators. In turn these units will probably be among the most static of those in the wing. The MWHS and MWSG already have numerous shelters, which, although not ISO compatible, are comparable in size and weight to those contemplated for the containerized generator.

This indicates that the WERS' 200kW and possibly some 100kW generators are candidates for containerization, while the smaller sized units should remain mobilized to maintain flexibility in meeting overall requirements.

b. Marine Air Control Group (MACG)

The MACG "provides, operates and maintains the Marine Air Command and Control System " [23, p. 107]. Two of its subordinate units, Headquarters and Headquarters Squadron (H&HS) and the Forward Area Air Defense Battery (FAADB) receive generator support from WERS in MWSG, while remaining subordinate units are all self-sustaining.

The Marine Air Support Squadron (MASS), Marine Air Control Squadron (MACS), and the Marine Wing Communications Squadron (MWCS) provide command, control and communications support. Major mission areas are: [23, p. 20-21]

MASS--control of anti-air warfare.

MACS--control of close and direct support aircraft.

MWCS--communications for wing headquarters and the wing air command and control system.

All are large power consumers and have considerable numbers of modularized operations and maintenance shelters. MACS must be capable of deploying as an integral unit, while the MASS must be capable of displacing in increments (i.e., echelons).

Accordingly, both 200kW and 100kW generators in these units are candidates for shelterization.

The Light Anti-Aircraft Missile Battalion (LAAM Bn) provides surface-to-air missile defense (HAWK) against air attacks. It must be capable of rapid movement and operation of its subordinate units--firing batteries--separate from the battalion headquarters. Again, it is a large power consumer having quantities of shelters, and it follows that the 200kW generator units are prime candidates for shelterizing. Given the LAAM Bn requirement for operation of missile batteries at remote locations, at least a portion of the 100kW units should be trailer-mounted.

c. Marine Air Groups (MAG)

In the Marine Air Groups (MAG's), both fixed wing and helicopter, the H&HS provides its own electric power

support as well as supporting its flying squadrons. Therefore, as with MWSG, the 100kW and smaller units should remain trailer-mounted in order to provide flexibility, while the 200kW generators are candidates for shelterization.

The Marine Air Base Squadron (MABS) in each MAG has the mission of providing "air base facilities and services" [23, p. 26] for its parent MAG. As such it is a relatively static unit; accordingly, both 100kW and 200kW generators are candidates for shelterization.

3. Force Service Support Group (FSSG)(Figure 6)

As noted earlier, the FSSG is the primary combat service support unit for a MAF. Were the FSSG to operate as an entity on a continuous basis, virtually all generators could be shelterized. However, it must be prepared to provide detachments of support for deployed MAGTF's of MAU and MAB size. Flexibility to meet this requirement could be achieved by retaining 60kW and smaller units on trailers and 100kW and 200kW units as candidates for shelterization. This rationale can be applied to all units in the FSSG.

Figure 18 summarizes the preceding discussion and shows generator sizes in each unit which are candidates for shelterization. Were all these candidate generators to be shelterized, based on the estimated total numbers of generators shown in Figure 18, some 192 200kW generators would be involved. Of the total of 330 100kW generators, probably one half to two thirds (i.e. 165 to 200) would eventually be selected for shelterization.

UNIT	3kW	30kW	60kW	100kW	200kW	REMARKS
<u>DIVISION</u>						
INFT. RGT.	X	X	X	--	--	
ARTY. RGT.	X	X	X	X	--	
RECON. BN.	X	X	--	--	--	
DSG	X	X	X	X	--	Supports HQ Battalion
<u>WING</u> (See Figure 5 for Abbreviations)						
<u>MWSG</u>						
WERS	--	X	X	(X)	(X)	Supports: H&MS, MWSG; UMGR; UMCJ; MWHS; H&HS, FAADB MACG.
<u>MACG</u>						
MASS	--	--	X	(X)	(X)	
MWCS	--	X	X	--	(X)	
MACS	--	--	--	--	(X)	
LAAM BN.	--	--	--	(X)	(X)	
<u>MAG (HELO/FIXED WING)</u>						
H&MS	--	X	--	X	(X)	Supports all organic flying squadrons.
MABS	--	X	--	(X)	(X)	
<u>FSSG</u>						
H&S BN.	X	X	X	(X)	(X)	
SUPPLY BN.	--	--	--	(X)	(X)	
MAINT. BN.	--	X	X	(X)	(X)	
ENGR. SPT. BN.	--	X	X	--	(X)	
MOT. TRANS. BN.	--	X	X	--	--	
MED. BN.	--	X	X	--	(X)	Supports dental companies.
	175	283	167	330	192	Estimated FMF total by type in "long range" generator plan

SOURCES: MCO 11310.10A (AMMENDED)
 FMF TABLE OF ORGANIZATION M3449x (FSSG)
 M1869x (DSG)
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NOTES: SHELTERIZATION CANDIDATES INDICATED BY X

Figure 18. Candidate Generators for Shelterization

Following the conclusions of Section IV, and putting 100kW units in ten-foot shelters and 200kW units in 20-foot shelters, both with associated MEPDIS equipment, between 165 and 200 ten-foot shelters and 192 twenty-foot shelters would be required in the Fleet Marine Force.

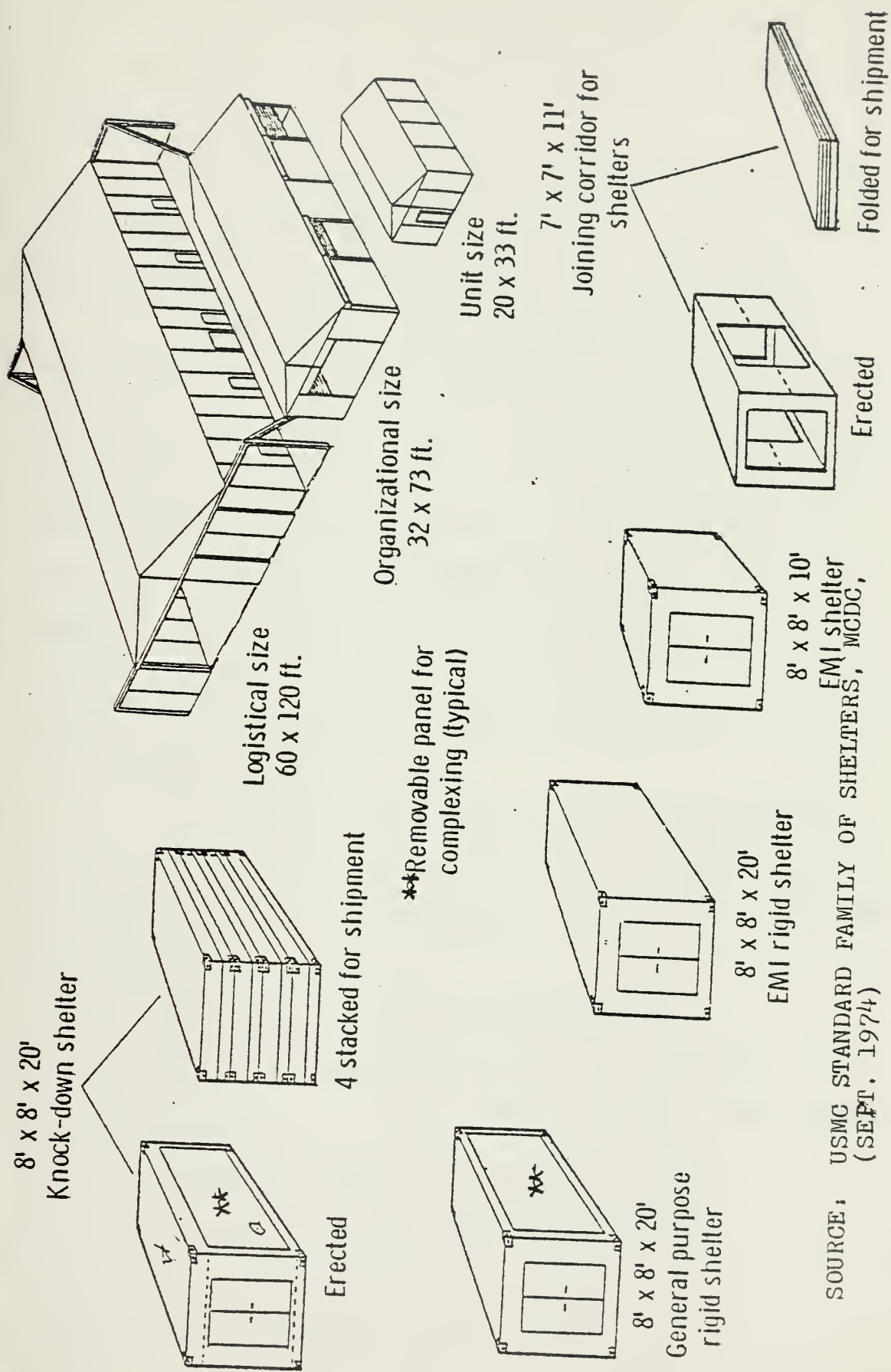
D. ADDITIONAL CONSIDERATIONS

1. The "Shelter Study"

The preceding discussion has been predicated on adoption of a container system along the lines recommended in the Container Study. While it can be reasonably projected that containerization will influence operations at least to the extent envisioned in that study, it is possible that there will be an even wider implementation.

The container study terminates all large and intermediate container distribution at the Logistics Support Area (LSA), (See Figure 16). A subsequent study, Determination of FMF Expeditionary Shelter System Requirements [24]--hereafter the "Shelter Study"-- evaluated use of a family of standard shelters and a transportation medium (the logistics trailer) for maintenance and supply functions.

Figure 19 illustrates the shelters in the standard family. They include both "knock-down" (60'X120', 32'X73', and 20'X33') and rigid types, all of which are transported in the standard 20-foot ISO configuration. The shelter study strongly recommends adoption of the shelter family, not only for maintenance, but for operations and support functions.



SOURCE: USMC STANDARD FAMILY OF SHELTERS, WDCDC, (SEPT. 1974)

Figure 19. The USMC Standard Shelter Family

Significant advantages would accrue not only costwise [24, Enclosure (1), p. 3A7, but in increased efficiency, equipment maintainability and readiness.

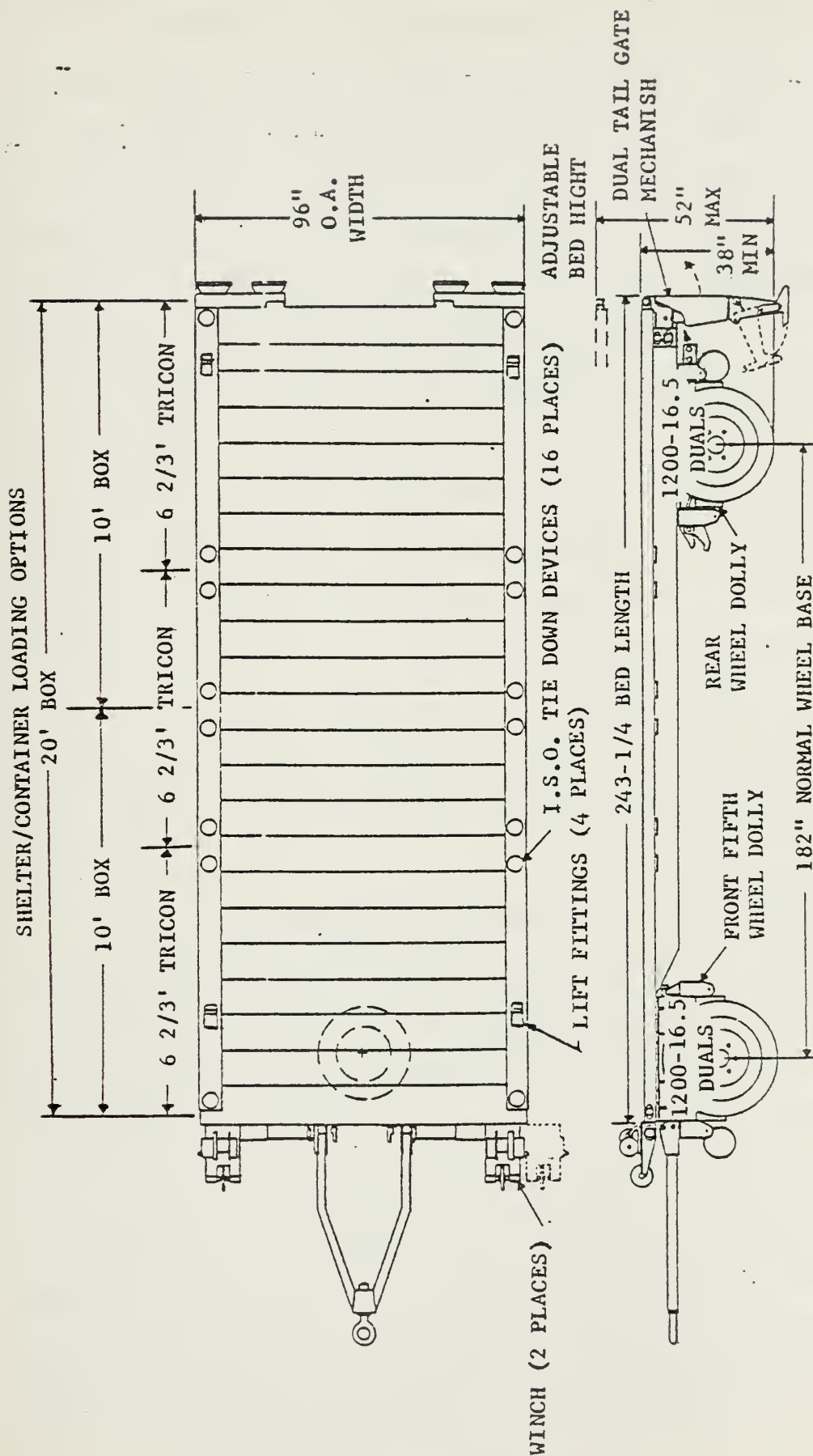
Mobility for shelters would be provided by the logistics trailer shown in Figure 20. A total of 237 of these trailers would be required for each MAF [24, p. 37

If the shelter study recommendations were to be adopted--and at this time there has been no definite indication of what action will be taken--virtually every unit would have shelters. This in turn means that the LSA limit envisioned by the container study would be superseded. In turn, the value of having generators trailer-mounted for ready mobility would be reduced, since the prime function of the logistic trailer would be to transport ISO compatible loads--both containers and shelters--throughout the area of operations.

It is beyond the scope of this study to fully consider the implications of the shelter study, but the attractiveness of the widespread, if not total, generator shelterization is obvious.

2. Cost-Effectiveness Considerations

Given the tentative nature of this study and the indefiniteness of the final extent of the overall shelterization/containerization, a detailed analysis of the cost-effectiveness of generator shelterization will not be undertaken. It is appropriate to include a discussion of the relevant factors for such a study.



SOURCE: USMC STANDARD FAMILY OF SHELTERS AND LOGISTICS TRAILER, MARINE CORPS DEVELOPMENT CENTER (SEPT. 1974)

Figure 20. General Purpose Logistic Trailer

Shelterizing 100kW generators would involve trading one dedicated trailer (M-353) per generator for a shelter. For the 200kW generators there would be no trade-off, only the additional expense of a 20-foot shelter per generator. Freed generator trailers are suitable for other purposes, but there is no ready alternative use for them, consequently, their only value may be for sale as surplus.

The avoidance of shed construction for generators has been previously mentioned. The Navy Civil Engineer Support Office (CESO) estimates that an 18'X33' generator shelter contains \$275 worth of materials (in CONUS, exclusive of transportation) and takes 200 manhours to erect. Such a shelter would typically accommodate three 100/200kW generators. Cost avoidance in construction is reinforced by the reduction in construction effort in an advanced base situation. This is highly desirable in view of the perpetual paucity of construction assets.

As a corollary to savings in environmental protection, shelterizing generators would permit a reduction in the amount and quality of paneling now required around generators. This paneling must provide environmental protection and transit protection in addition to directing cooling air around the unit. If the generator were shelterized, only the cooling function would be required, and this could be accomplished with fewer and lighter panels. Savings in generator acquisition costs are impossible to estimate without a detailed engineering analysis, but are likely to be significant.

Perhaps the most significant benefit to be realized-- and the most difficult to quantify--would be the consolidation of the generator and the distribution system in a single enclosure. Operationally, all components required for providing service would be at the same location at the same time, and installation delays would be minimized. Administratively, the possibilities of pilferage or inadvertent misrouting would be significantly reduced.

If the "Container Study" concepts are adopted, shelterized generators would compose only a minor portion of overall requirements for transportation/MHE. It is considered that their needs for movement, which would be intermittent rather than continuous, could be absorbed by existing and envisioned transportation/MHE assets.

Similarly, no transportation/MHE dedicated to generators would be required if the "Shelter Study" concepts are adopted.

E. SUMMARY CONCLUSIONS

The discussion in this section has addressed itself to the organizational and mission factors relevant to a generator shelterization decision. It is apparent that these considerations preclude total shelterization. All 200kW and one half to two-thirds of the 100kW generators in Marine Air Wing and Force Service Support Group units should be shelterized, while all Marine Division generators should remain on trailers. Implementation of the Shelter Study would significantly increase the scope of generator shelterization.

VI. CONCLUSIONS

It is evident that the restructuring of the United States shipping industry and the impending demise of the break-bulk cargo fleet is forcing the military to realign its logistic support organization. There are significant advantages to containerization in both peacetime and in conflict situations. There are substantial savings to be realized in manpower, shipping assets required, transit and unloading time, and pilferage.

The most worrisome aspect of container utilization at this time is the absence of an operational OSDOC system for use in advanced-base situations.

The central issue of this study has been the application of container technology to Marine Corps' generators. Continued trailer mounting of generators and their handling as vehicle loads in break-bulk or amphibious shipping provides the maximum operational flexibility and mobility. It is not responsive to the challenge and opportunities of containerization. Further, it does not recognize the potential constraints which will be imposed by shipping availability in the future.

Trailer-mounted generators cannot be satisfactorily transported in either closed or open (i.e., flatrack) containers. Skid-mounted generators can be transported in containers. This appears to be an advantageous method of

moving resupply generators into an operational area. Replacement trailers would have to be handled as bulk/vehicle cargo.

Generators and associated distribution equipment can be transported in shelters. At the final destination generators can be operated within shelters. Relative advantages and disadvantages associated with shelterization are summarized as follows:

Advantages

- consolidation of generator and distribution system.
- environmental protection for generator and distribution system (in storage, transit and operation).
- compatibility with ISO standards and container transportation assets.
- pilferage protection.
- reduction in generator paneling required.
- operating protection and safety provided.
- extension of projected containerization concepts.
- attractiveness increases with adoption of "shelter concepts."

Disadvantages

- requirements for MHE and transportation assets.
- limitation on ready mobility.
- cost of shelters.
- probable need to retain a portion of trailer-mounted generators.
- limited capacity for container aboard break-bulk and amphibious shipping.

In summary, containers can be utilized for transportation of skid-mounted generators, but not trailer-mounted units.

Operating generators and associated MEPDIS can be shelterized, particularly 100kW and 200kW units. A decision as to whether generators should be shelterized is contingent on the container system ultimately adopted by the Marine Corps and action taken on the current shelter study.

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